EPRI Advanced Reactor Strategic Program

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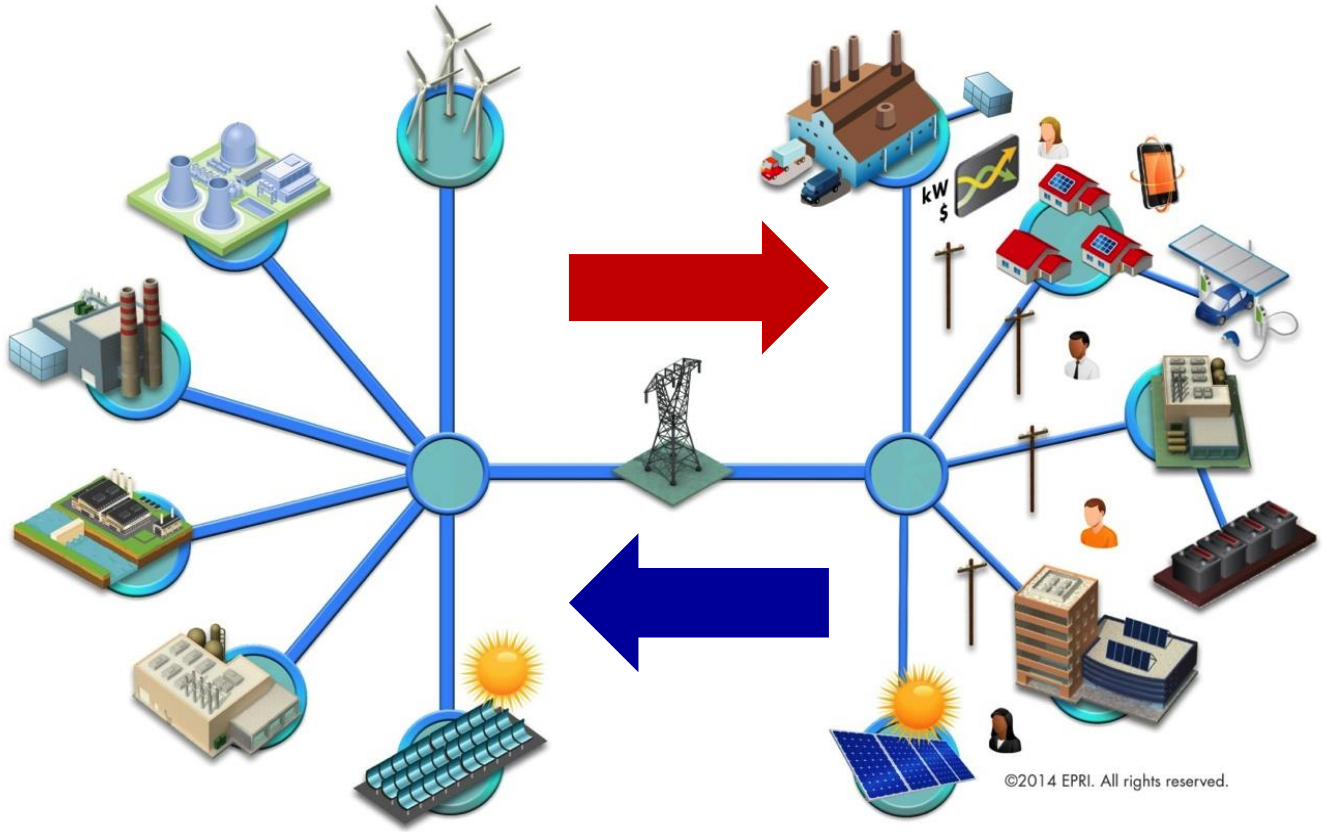
EPRI…Born in a Blackout

- Independent, nonprofit center for collaborative public interest energy and environmental research
- International membership comprising 25% of overall R&D funding (40% of nuclear)
- EPRI members represent > 90% of U.S. electricity generation (100% of nuclear)
- EPRI programs engage ~80% of nuclear operators worldwide

New York City
The Great Northeast Blackout, 1965

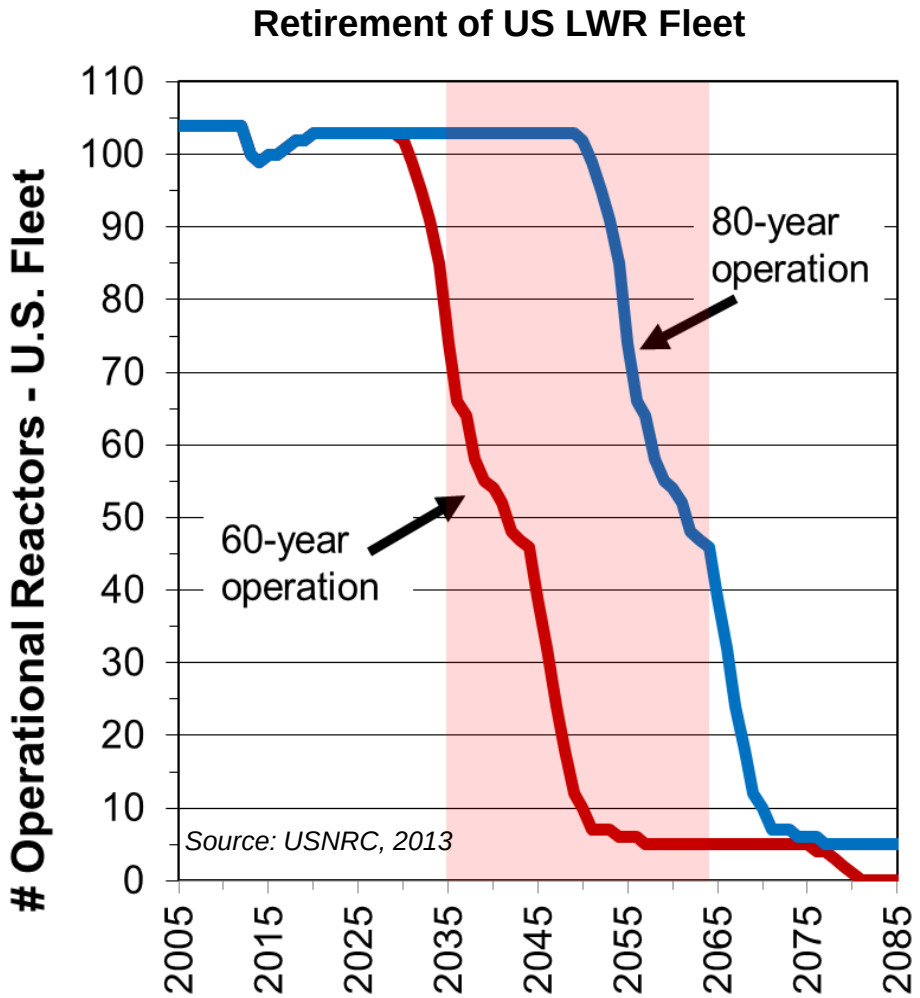
The Commercial Environment for Nuclear is Changing

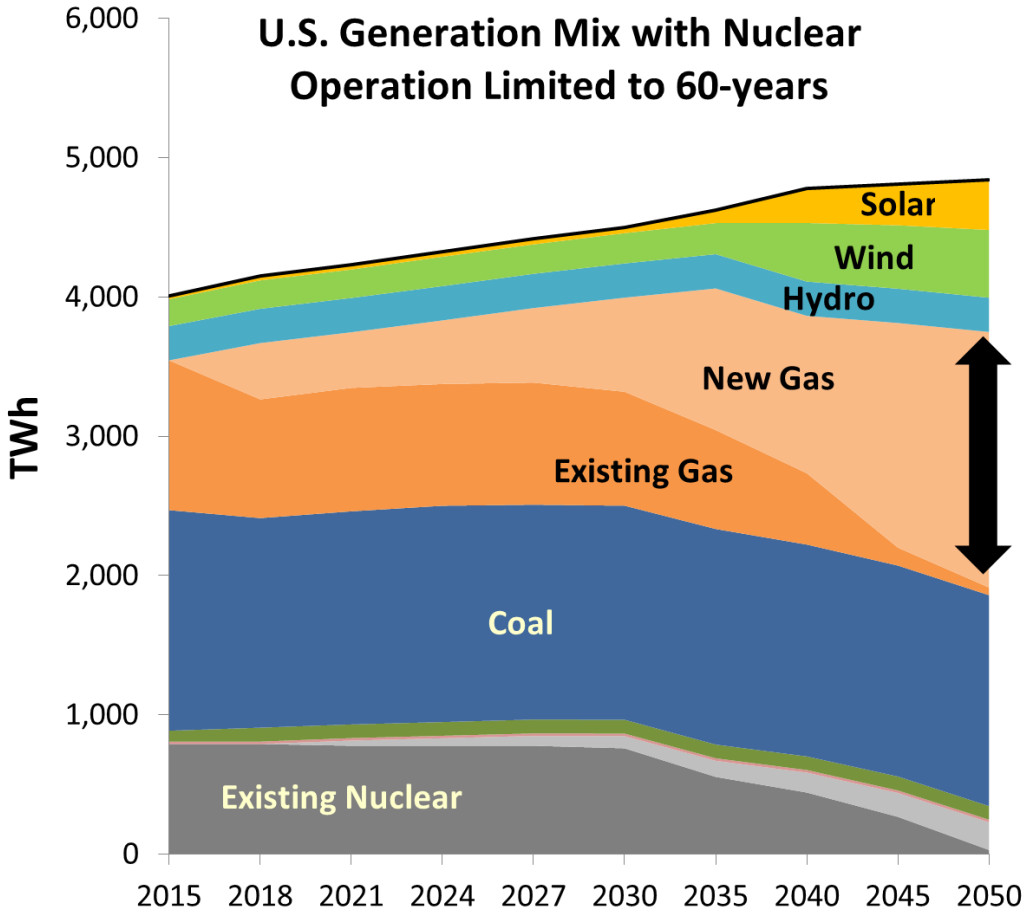
- Electric utilities and grid operators face increasing challenges to maintain power quality, system stability – including adequate energy and capacity
- New paradigms are needed to support future energy infrastructure:
  - flexibility
  - resilience
  - integration
- Uncertainty is only certainty:
  - price of natural gas?
  - price of carbon emissions?
  - new technology (or lack thereof)?
  - subsidies for renewables?



Opportunity in Uncertainty: The Driver for New Nuclear?

- Trillions of USD in new energy infrastructure investment needed in U.S.
- Satisfying future energy demand AND carbon limits becomes unrealistic without nuclear

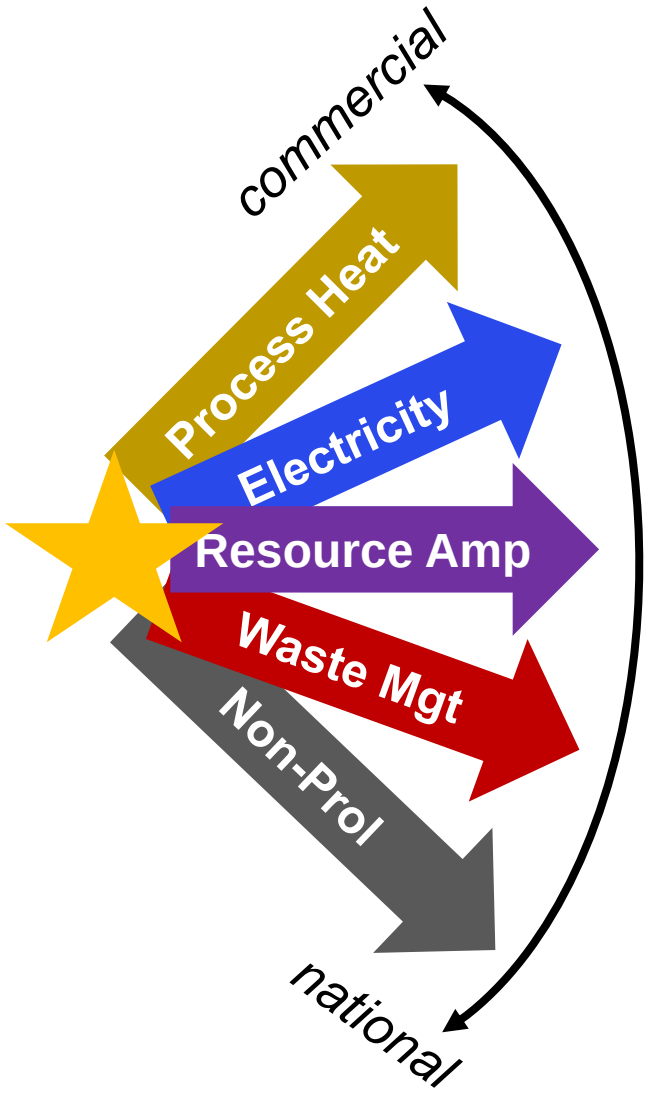




Utilities are seeking options for intensive, low carbon energy – not silver bullets.

21st Century Role for Advanced Reactors

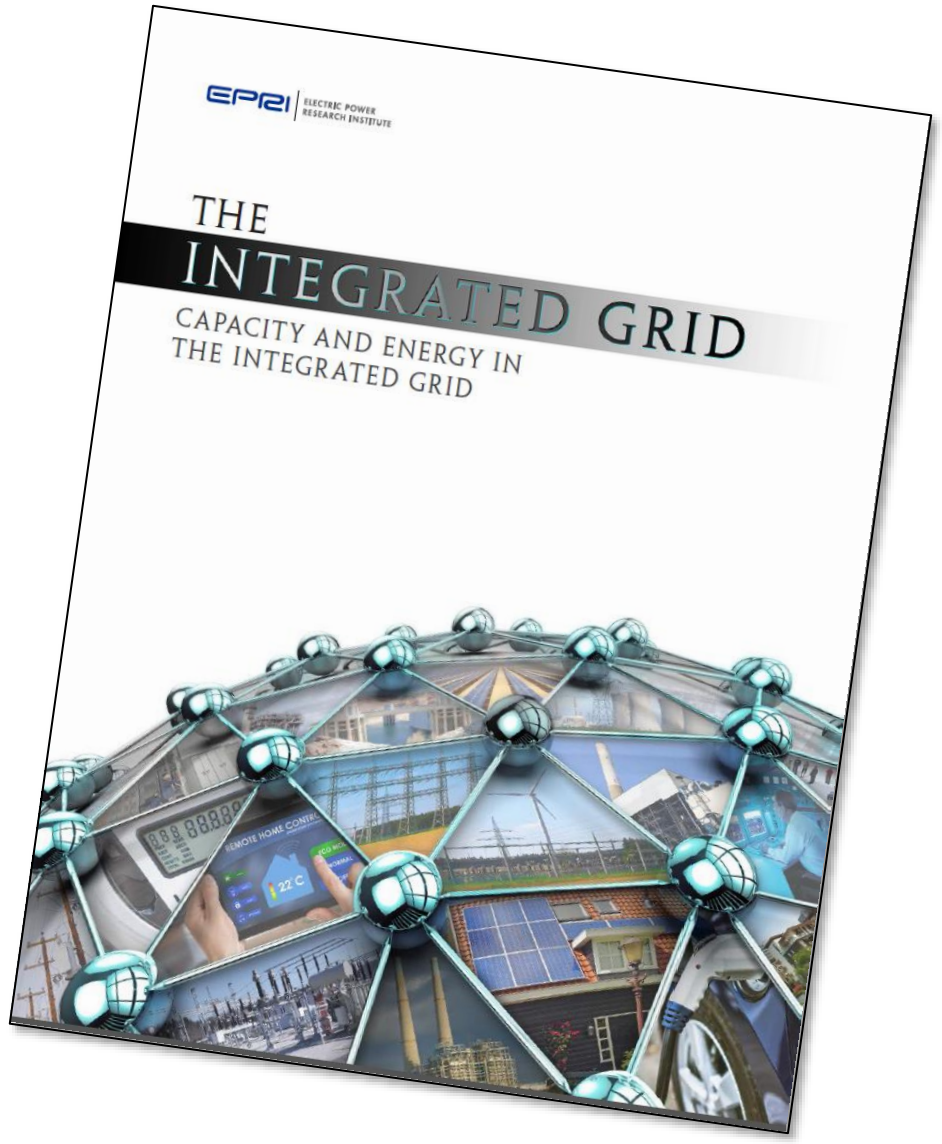
- No Generation IV without healthy Generation II/III
  - operation of new ALWRs will span the century
  - loss of viable nuclear industry infrastructure not easily reversed
- Sustained future will require more compelling business cases derived from advanced reactor attributes:
  - high efficiency electricity generation and/or alternate products via high temperature operation
  - enhanced passive safety from inherent physical properties
  - natural resource amplification via high conversion or breeding
  - actinide management
  - **asset flexibility: operational, deployment, product**



Clear commercial drivers and requirements have not been articulated.

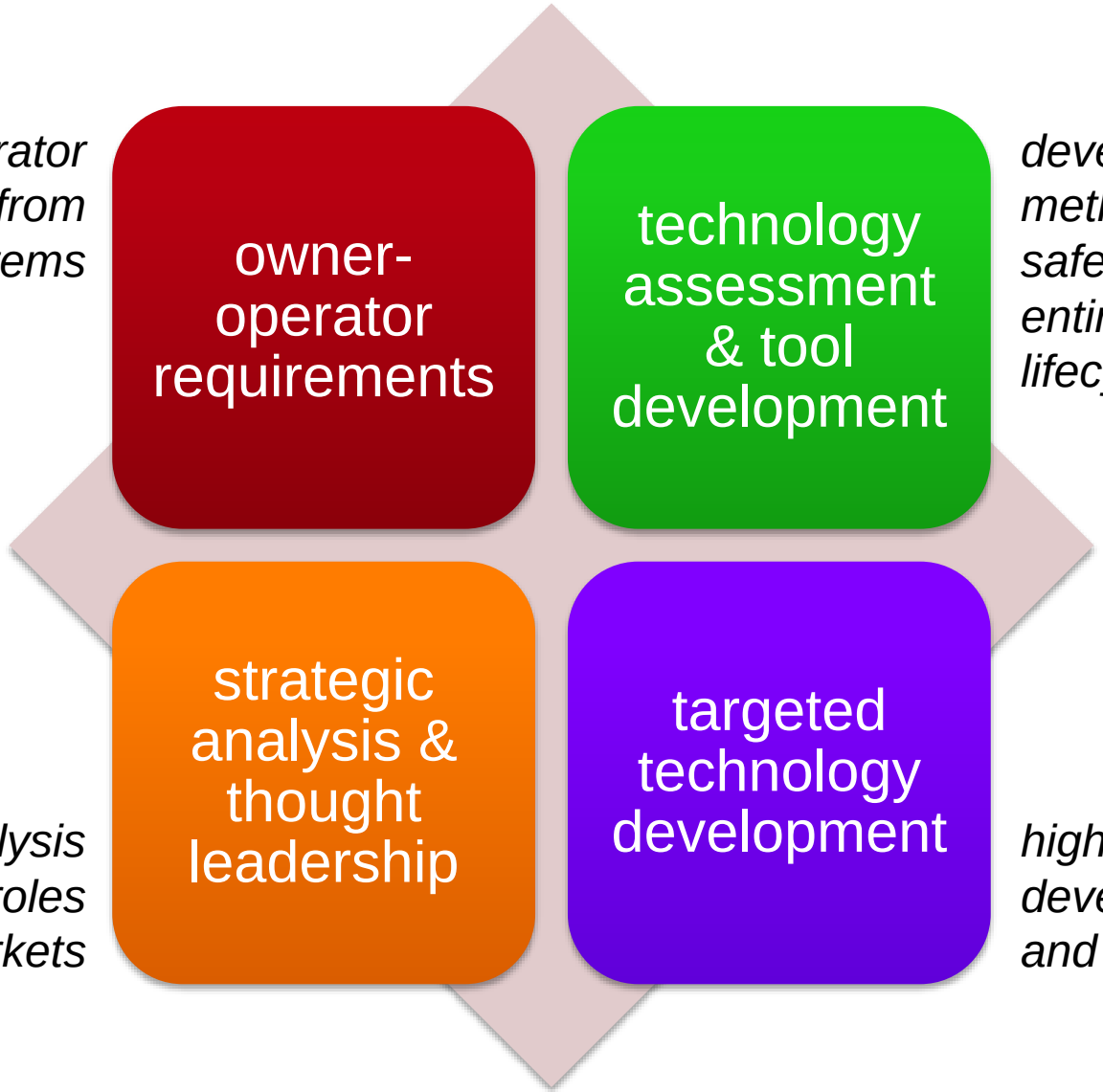
EPRI Advanced Reactor Strategic Program

- Vision: EPRI will play a leading role to enable commercialization of advanced nuclear generation on timeframes and at scales needed
  - ***collaboration and leveraging of resources for impacts commensurate with those of the Advanced Light Water Reactor (ALWR) program***
  - ***mature designs, technology demonstrations and FOAK construction by 2030s***
- Objective: Build foundation for advanced nuclear technology now for real options later
- Four-year funding commitment supporting a broader EPRI strategic focus on a flexible, resilient and integrated energy infrastructure
- **Technical Advisory Group (TAG) established to guide RD&D program and facilitate coordination**



EPRI Advanced Reactor Strategic Program: Research Focus Areas

elaborating owner-operator expectations and needs from advanced nuclear systems



developing best practices and methods for application of safety analysis tools over entire design to operation lifecycle: PPHA to PRA

economic portfolio analysis to better define nuclear roles in future energy markets

high temperature material development, characterization and qualification

Value Proposition for Advanced Reactor Owner-Operator "Requirements"

- Promote alignment of technology developers and attributes with potential owner-operators
  - facilitating early customer buy-in
- Stabilize definitions for key attributes and requirements
  - emphasis on standardization and clarification of terms, attributes and requirements rather than prescribing them
  - example: *define maneuverability for plant startup and shutdown, load following and frequency control…*)
- EPRI Approach: Initial emphasis on policy and high-level attributes
  - focus first on mission (electricity, process heat)
    - then design classes and variants (HTGR, MSR, SFR)
      - with potential for adding "bid spec" level detail

Advanced Reactor Owner-Operator Requirements Document (ORD) Scoping Study

Phase I: ORD Scoping Study

- High-level review of the existing EPRI ALWR Utility Requirements Document (URD) and other similar resources to determine feasibility of ORD development
  - Mapping of high-level ALWR URD policies and requirements to a technology neutral framework
  - Identifying gaps arising due to the technological neutrality
  - Eliciting input from stakeholders on owner-operator objectives, associated technology attributes and requirements, and information needed by developers, vendors and constructors
- Scoping study report complete by August 2016

Phase II: Development of ORD - High Level Requirements

- *Follow on activity to further develop GEN IV ORD based on expanded engagement with community (including non-utility owner-operators)*
- *Could start in Fall 2016*

Expanding the Concept of Flexibility for Advanced Reactors

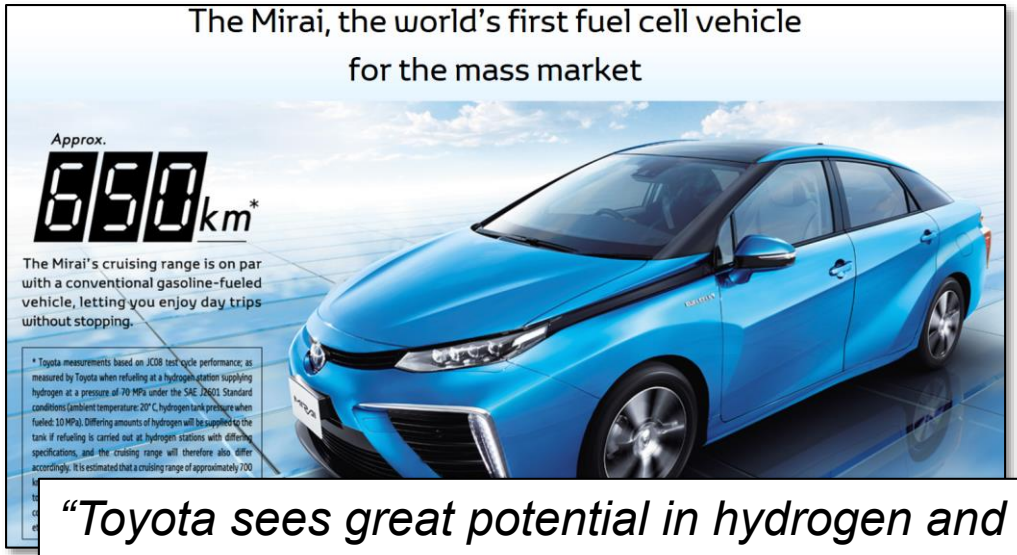
Attribute	Sub-Attribute
Operational Flexibility	Maneuverability
	Compatibility with Hybrid Energy Systems and Polygeneration
	Diversified Fuel Use
	Island Operation
Deployment Flexibility	Scalability
	Siting
	Constructability
Product Flexibility	Electricity
	Process Heat
	Radioisotopes

- Greater ability to optimize new plant siting, procurement, construction and operation
- Greater ability to adjust and repurpose plant operation after construction
- Greater ability to adjust and repurpose technology platform post commercialization

- ***Is flexibility the missing link between the potential of advanced reactor technology and the compelling business cases sought by customers?***

Are Storable Commodities and New Markets a Key Future Play for Nuclear?

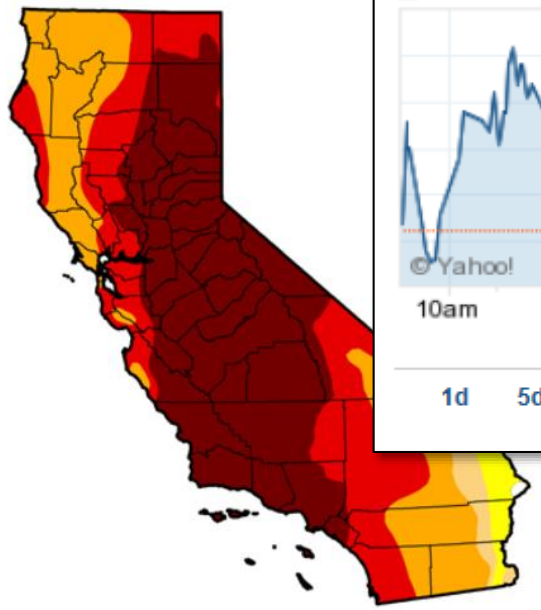
- Hydrogen as a dominant energy carrier for transportation?
  - alternate or complementary path to deep decarbonziation of industrial economies
  - displacing petroleum
  - leap frogging battery technology



"Toyota sees great potential in hydrogen and fuel cell vehicles."

http://www.toyota-global.com/innovation/environmental_technology/fuelcell_vehicle/

- Potable water as the "oil" of the 21st century?
  - 50% of world's population within 200 km of coast
  - fresh water comprises only 2.5% of earth's water; of this only 1% is readily accessible for use
  - commodity trading of water has begun



Together…Shaping the Future of Electricity